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RESEARCH PAPER

Design of Efficient Skill Training Supply Chain using Network Data Envelopment Analysis

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ABSTRACT
Providing skills training is an essential need of different societies. Considering the significance of the role of skill training in empowerment and employment of individuals through the training of skilled labor required by the labor market and industry, in this study the supply chain of skills training has been designed. In the proposed supply chain, according to the skill training aspects, a network structure is conceptualized to include appropriate factors in different layers of the supply chain. Evaluating the performance of the supply chain is handled applying a network data envelopment analysis. Network Data Envelopment Analysis (NDEA) is an efficient method analyzing all the factors included in the evaluation network. Among the NDEA models, the output-oriented Bunker-Chaarns-Cooper (BCC) model was selected due to the importance of the output of the supply chains of the skills training. In addition to efficiency, the concept of complementary loss is also introduced to validate the results. The research findings show the efficiency of various factors in the stages of the designed network. On the other hand, unlike the classic DEA method, which shows the maximum efficiency of a factor, in the proposed network model, the efficiency priority is calculated and the efficiency is determined at each stage of the supply chain.

KEYWORDS: *Skills training; network data envelopment analysis; Skill supply chain; performance appraisal.*

1. Introduction

One of the most important social issues ahead is the challenges of employment and unemployment in societies. Employment is undoubtedly a basic necessity in human life. In fact, unemployment causes frustration and social and political crises and their deviation. Employment is one of the most important issues discussed by policymakers in different countries of the world. Because most of the countries in the world, from industrial societies to developing third world countries, are somehow facing the problem of unemployment. There is also a deep link between education and employment. Given the population growth in the last two decades and the lack of skills of many people, even university graduates, and ultimately mass unemployment of society, this issue is one of the most important social challenges. In today's fast-paced and evolving world, there is ample evidence that education plays a central role in opening up bottlenecks and creating advanced technologies. In the current situation, one of the factors that change the economic, social and industrial conditions of a country is to provide education and improve skills to individuals. Investing in the development of a country's skills through skills training is a vital component of human capital development. In today's world, development is not possible without skill training. Skills training, while providing the basis for sustainable growth and development, will address current issues and problems such as poverty, social and cultural disorder, unemployment of university graduates and the massive dilemma of other unemployed [1].

The main factor limiting the ability to develop the workforce is the lack of knowledge of skilled jobs in society. The public prefers to learn general and higher education in society, and its loss leads to an imbalance between supply and demand in the labor market. Skills training has a lower value than higher education, and this has led to an influx of people to enroll in universities,

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and ultimately leads to high unemployment in the community. High unemployment is exacerbated by the skills gap that exists in countries. These trainings lead to the desired results in countries that have emphasized these trainings as a way to provide vital skills to the industry [2]. Skills training plays an important role in developing the essential skills of the labor market. By limiting the role of skills training, the education system has failed to prepare its students for entry into the global economy [3].

Therefore, lack of skills is one of the causes of crisis and unemployment. Obviously, in order to be employed and accept the specialized responsibilities of society, one needs to acquire skills throughout one's life. Skills training is one of the main needs of society and plays an important role in the era of sustainable development. The development of skills training increases human capital, which leads to sustainable political, economic, social, cultural and environmental development. These trainings have been accepted and emphasized by international organizations such as UNESCO and ILO as one of the pillars of sustainable development. Through the provision of skills training, it is expected that by improving the knowledge and skills of individuals, it will play a major role in reducing unemployment in society and contribute to economic and social development [4].

In industrial units that face a tendency for the workforce to move, more than average, and labor costs are much higher in this sector, focusing on creating meaningful work and instilling a sense of belonging to the workforce enables collections to reduce staff turnover [5]. Empowering people; Strengthens the quality of work life, teamwork spirit and the effectiveness of work activities. Communities need to empower individuals as well as encourage empowerment leadership. Empowering leadership implies sharing power and motivating people to strive for superior performance. Given the role that individuals play in communities, it is important to understand the impact of their empowerment on work outcomes. Empowering people enhances their performance, job satisfaction, service commitment, customer satisfaction, productivity and business growth [6,7].

There is an accepted scale for psychological empowerment in Spritzer's multidimensional approach that includes aspects of meaning, competence, self-determination, and impact. Empowerment is semantically aligned with the ideals and standards between an employee and his /her work. Competence comes from the employee believing that he or she has the skills and abilities to succeed [5]. Education is considered an important factor in economic growth, employment and social inclusion. However, the economic crisis has increasingly highlighted the need to achieve educational goals in the most efficient way [8]. Over the past few decades, educational policies have been identified in light of the growing role that skills and educational outcomes play in the economic and social development of countries and societies [9].

The main contribution of the paper follows here. Considering the important role of skills training in empowerment and employment of people in society, designing the supply chain of skills training is a very important and necessary. Since skill training requires resources, processes and user, a supply chain is configured including resources in the first layer, processes in the second layer and users in the third layer. It should be note that in each layer, multiple elements exist and thus a network of elements and their interconnections is formed. In addition, due to the increase in efficiency and effectiveness of training, there is a need to evaluate the performance of the training supply chain. In this research, for the first time, the supply chain of skill training has been designed and its efficiency has been measured. To evaluate the efficiency, of the skill training supply chain and due to its network structure, a network data envelopment analysis is adapted and employed.

The paper is organized as follows. Next, the related literature about the skill training and evaluation is reviewed and extracted. In Section 3, the network skill training problem is stated and the proposed skill supply chain following the network DEA model are depicted and described in Section 4. Section 5 presents an implementation study in Iran skill training environment. We conclude in Section 6.

2. Literature Review

Reviewing the researches in the field of education supply chain design, it was observed that in the conducted researches, education supply chain design has been done for higher education and postgraduate studies, but no research has been done on skill trainings so far. Today's world, due to the increasing acceleration of science and awareness, is characterized by constant change and complexity of structures. In such circumstances, only successful organizations are those that have appropriate and up-to-date information about the performance of their organization and make the right and timely decisions for the continuous improvement of the organization in accordance with the changes in the world [10].

In recent years, service providers have developed significantly rapidly. Hence, the need for creative activities to accelerate economic growth is felt more than ever. In the service supply chain, unlike the production supply chain, customers are considered as an active partner in the operation process. The operation is performed on the part provided by the customer. This means that in the service chain, customers are the main suppliers of the process [11]. In other words, in the customer service business, they have a dual role of providing the customer. In today's highly globalized environment, continuous performance measurement is the key to any business success.

Although several components can be studied as an educational variable, academic performance is recognized as a criterion for achieving a higher level of education and entering the business environment [12]. Hence, it has received more attention than other components. Nowadays, students' academic performance has been considered as an important indicator for evaluating educational systems. In addition, good academic performance has always been important for teachers, students, parents, theorists, and educational researchers [13]. Therefore, it can be argued that students' academic performance is important for not only themselves and teachers, but for families, the education system and society. Since students are the main part of any educational system, special attention should be paid to this group and the way to achieve their goals, and as a result, the factors that affect students' academic performance should be addressed [14].

Measuring educational efficiency using artificial intelligence methods as a leader in education is one of the most important mechanisms and its use, which seeks to increase efficiency, effectiveness and ultimately improve the quality of education, is essential for education agents [15]. It is fundamental because the improvement, transformation and production of quality for society and organization must be formed within the educational system [16]. Due to recent developments in the field of measuring efficiency and its application in social life, increasing the quality of education indicates that policy-making and decision-making in education can be done by relying on the results with full accuracy and sensitivity and conscious efficiency [17]. Universities today are under similar market pressures. Significant changes in competition have led colleges and universities to embrace the corporate business thinking process to the point where students are now treated as customers [18].

In this section, we review the table of other authors' research on the educational supply chain:

Tab. 1. Summary of research conducted in the field of education supply chain

Author Name	Title	Supply Chain	Effective variables	Research Methods	Year of publication
Antonio and Lau [19]	Educational supply chain management: a case study	✓	Student, knowledge, Supervisors, academic departments, professors, non-academic departments	Interview	2007
Habib and Jungthirapanich [20]	Research Framework of Educational Supply Chain Management for the Universities	✓	Student, society, education development, education assessment, education customers	Exploratory	2009
Tramarico et al. [21]	BENEFITS ASSESSMENT OF TRAINING ON SUPPLY CHAIN MANAGEMENT	×	Training, individual company, organizational company,	AHP	2015
Badea et al. [22]	Competency Training in Collaborative Supply Chain Using KSA Model	×	knowledge, skills, attitudes	survey study	2015
Dubey and Gunasekaran [23]	Shortage of sustainable supply chain talent: an industrial training framework	×	Training, sustainable, talent	Interview	2015
Basu et al. [24]	Education Supply Chain Management Model to Achieve Sustainability in Private Universities in Malaysia: A Review	✓	higher education, Educational Supply Chain, Sustainable Practices, Private Universities	questionnaire	2016

Mandic et al. [25]	Effects of cycle skills training on children's cycling-related knowledge, confidence and behaviours	×	Skills, knowledge, confidence, behaviors	Statistics	2017
Jauhar et al. [26]	Sustainable educational supply chain performance measurement through DEA and differential evolution: A case on Indian HEI	✓	Educational supply chain management, Data envelop Analysis, Performance measurement	Comparative study	2017
Silva et al. [27]	Managing micro and small enterprise supply chains: A multi-level approach to sustainability, resilience and regional development	×	Theoretical model for MSE supply chain Sustainability	(1) Semi-structured interviews, (2) field observations, and (3) secondary data.	2021
Derwik and Hellstrom [28]	How supply chain professionals learn at work: an investigation of learning mechanisms	×	Emerging economy, Regional development, Micro and small enterprise supply chains, Supply chain resilience	Interview	2021

As shown in Table 1, educational supply chain consideration and configuration were studied in [19], [20], [24], [26]. Further, [21] made use of AHP, as a multi-attribute decision making approach to evaluate the benefits of a training supply chain. According to Table 1, most of the studies ignored the multi-layer supply chain configuration for education and thus a detailed performance evaluation was missed. On the other hand, since there are several elements effective on training process, it is necessary to have a more comprehensive evaluation method capable to analyze all parameters, simultaneously. Because there is a need to evaluate the effectiveness of feedback-based training, the data envelopment analysis (DEA) is used to evaluate the performance of the training supply chain.

3. Problem Statement

Performance appraisal is essential to create a positive impact in communities and improve service quality. Reflection on different attitudes towards performance appraisal indicates that the evaluation system should be commensurate with the growth and development of organizations and be able to respond to their various dimensions. The only way for companies and organizations to continue, with the expansion of global markets, is to increase competitiveness and gain a sustainable competitive advantage among them. Today, competition between unique companies has given way to competition between supply chains. Therefore, calculating supply chain efficiency is one of the important issues because a process cannot be managed without measuring its efficiency. The efficiency and effectiveness of any organization is the result of the management performance and supply chain structure of that organization.

Evaluating the efficiency of decision-making units (DMU) is a basic element of effective planning, control and decision-making. In fact, measurement systems play an important role in monitoring, increasing motivation, improving communication and preventing mistakes in organizations, and as a result, these systems are an effective help for managers to review and improve goals and these are the current business processes of the organization. Evaluating the performance of education is one of the mechanisms that help to improve the learning process in various dimensions and provides a platform for improving and increasing the quality of educational processes.

Therefore, due to increasing the efficiency and effectiveness of training in skill-based organizations, reviewing the progress towards the set training goals, formulating correct training policies, identifying components that need more attention and obtaining information in order to make the right decisions, it is required to evaluate the skill training supply chain performance.

The most important objectives of this research are as follows:

- ✓ Designing a supply chain network for skills training
- ✓ Creating stability in skill training

- ✓ Provide training supply chain evaluation system
- ✓ Creating a feedback system for the effectiveness of training
- ✓ Provide a way for effective and lifelong employment of the target community

Research assumptions are listed below:

- ➢ The customer responds rationally to the questionnaires.
- ➢ All rules and regulations exist in the organization providing training.
- ➢ There are specialized instructors for training skills courses.
- ➢ Skills training based on the real needs of society is commensurate with the goals of sustainable development.
- ➢ The structure of the network data envelopment analysis model is based on the basic model.

4. Methodology

As mentioned in the previous sections, the supply chain of skills training is designed for the first time in this research. The supply chain of skill training is designed in two stages and includes the levels of basic factors (manufacturers), process factors (distributors) and external factors (customers). It should be noted that to design this chain, a section called information resources (needs assessment), which is not part of the main process of the training supply chain but is an integral part of it, was studied.

This section helps to design a more appropriate supply chain. The basis of training work is needs assessment and before designing the training supply chain, information resources and needs assessment should be done and based on the information obtained from this field, we should prepare the training supply chain. This section includes the following:

Technical resources: Specialized resources are considered in the field of education, which by combining them with specialized supply chain resources, a comprehensive and complete combination called training supply chain can be achieved. Here, technical resources are in fact educational models based on which skill organizations have designed their educational system. Like the Australian spectrum, US competency-based education, German dual.

There are a number of other educational models in this field that have also been inspired to provide the supply chain for this research.

Market needs: This section is mainly done by job centers or facilitators. This group identifies the needs of the labor market, businesses, factories, needs assessment systems, etc.

Feedback analysis: Analysis of training output from institutions or individuals who have benefited from the required skill training.

This chain is also repeated recursively. In this way, measures are taken to review the trainee's conditions in terms of training promotion and progress in the workplace after passing the training courses. Whether the trainee has succeeded in using the knowledge, skills and attitudes acquired from training in his profession or not, or whether he has entered the unemployed trainee after entering the skills market or not. In this way, the manufacturer will check the conditions and correct the defects of the system and will inform the supplier about the measures taken. This is where the concept of sustainability in skills training comes into play.

According to the structure of skills training, the two-tier supply chain designed for skills training is shown in Figure 1:

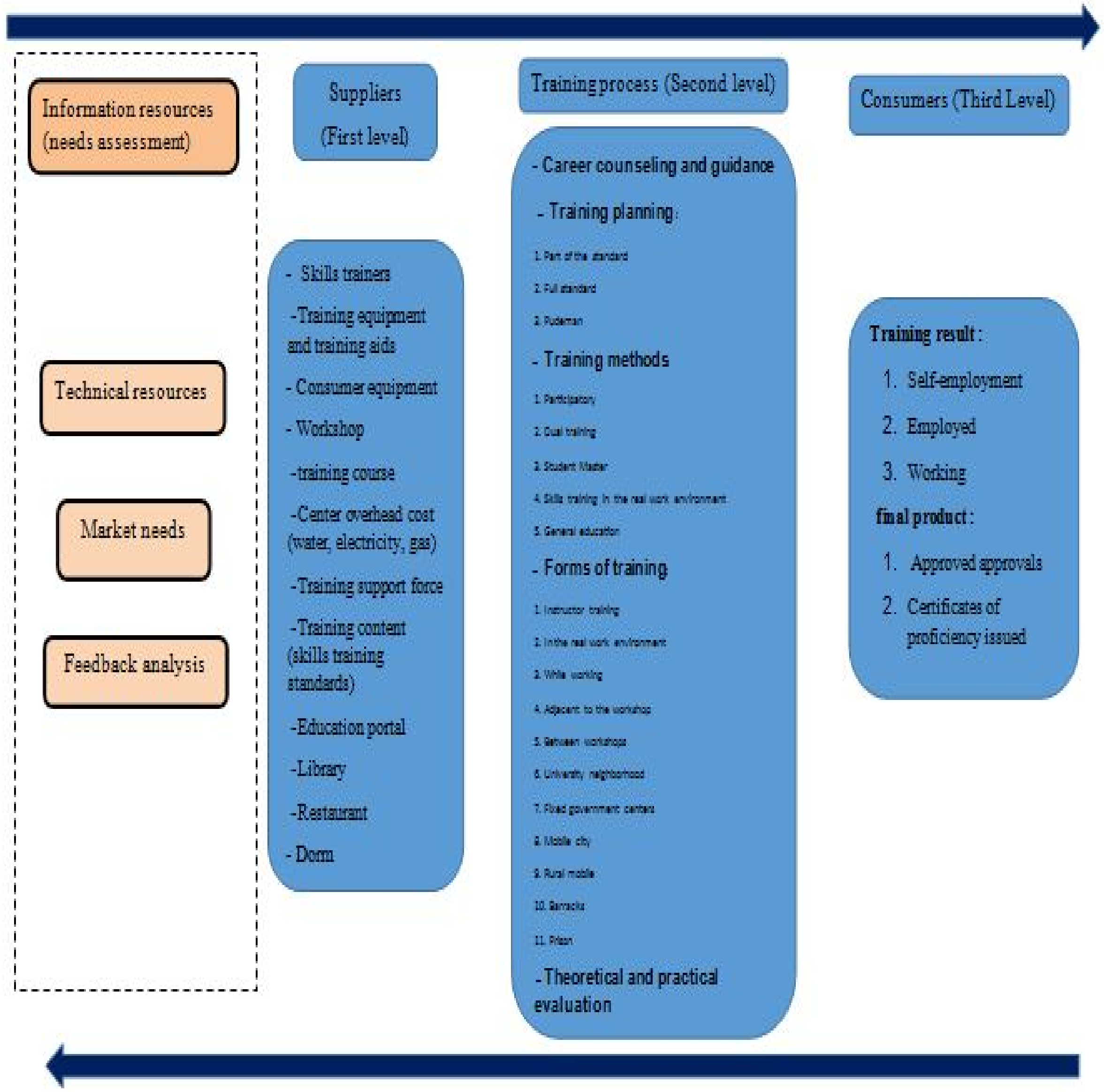

Fig. 1. Skills training supply chain

Therefore, to evaluate this chain, only three main levels are considered, which include: the first level (suppliers), the second level (training process) and the third level (consumers).

In this chain, the first level includes the following components: graduates of higher education (skills training instructors), training equipment and training aids, consumables, training workshop, training course, center overhead cost (water-electricity-gas), power Training support, training content (skills training standards), training portal, library, restaurant, dormitory.

The second level includes components of career counseling and guidance, training planning (part of the standard, full standard, module), training model design (participatory, dual training, student teacher, in-workplace skills training, general training), forms of training (Instructor training in real work environment, while working, workshop neighborhood, inter-workshop, university neighborhood, fixed government centers, mobile city, rural mobile, barracks and prison) and finally theoretical and practical evaluation.

The third level includes the outcome of education (self-employed, employed, employed), the final product (certifications issued, certificates of proficiency issued).

Since the supply chain of skills training is a network of upstream and downstream communications in various processes, all activities related to training flows and related financial and information flows, from the stage of basic factors, process factors and includes external factors and generates value through the supply of end products and services to customers. Its evaluation is very important.

As mentioned, evaluating this structure requires a method that measures the effectiveness of feedback-based training. After reviewing various articles and researches in the field of supply chain performance evaluation, we came to the conclusion that the appropriate method is data envelopment analysis (DEA). The DEA method has been widely used in evaluating the performance of educational institutions, systems and activities. Mathematically, the DEA method can be represented as a problem of maximizing the ratio between the weighted sum of outputs and the weighted sum of inputs for each institution (the sum of inputs and outputs are obviously standardized for calculating different units of measurement). Another reason that clarifies the appropriateness of the DEA method is due to the multi-Echelon skill supply chain, which can easily evaluate the performance of multi-level supply chains. Therefore, the network data envelopment analysis (NDEA) is used for this purpose. Other methods such as TOPSIS, AHP, ANP, Vikor, ELECTRE, etc. perform evaluation based on index and ranking, but DEA measures the efficiency of all factors present in the evaluation, which is an important point for policy making. DEA not only provides performance scores for inefficient (DMUs), but also provides boundary forecasts for such units on an efficient boundary.

4.1. DEA model

In 1978, Charns, Cooper, and Rhodes introduced what became known as the CCR (CCR). They generalized Farrell's initial analysis in multi-input-single-output to multi-input and multi-output. This model is called "data envelopment analysis" and was first presented in Dr. Rhodes' dissertation under Cooper's guidance in "Assessing the Academic Achievement of American Schoolchildren" in an article entitled "Measuring the Efficiency of Decision-Making Units" [29]. This model was built on the assumption of returns to a constant scale and its generalization to returns on a variable, decreasing and increasing scale has also been seen. The generalization of the CCR model to variable-scale returns was introduced by Bunker, Charns, and Cooper in 1984 and became known as the BCC model. In this model, returns to the incremental, fixed and decreasing scales are allowed locally [30]. These two articles are the basis of many performance analysis studies. After the introduction of the CCR and BCC models, other models were introduced to strengthen the DEA, and most of them had two orientations: input and output.

Since not all units operate at the optimal scale and it is not possible to scale equally and higher and lower than the maximum value observed for each of the inputs and outputs, returns to the variable scale are used. In this model, by changing a unit in the inputs, the outputs change in different proportions. In this chain, due to the importance of outputs, this change should be incremental. The purpose of this method is to increase efficiency by increasing output. In the process of evaluating the supply chain of skill training, we try to increase the level of output by keeping the level of inputs constant, so we use the output-oriented BCC method with variable scale.

In general, DEA is a multi-factor efficiency analysis model for measuring the relative efficiency of a homogeneous set of DMUs. Performance score in the presence of multiple input and output factors is defined as follows:

$$\text{Efficiency} = \frac{\text{Weighted sum of outputs}}{\text{Weighted sum of inputs}} \qquad (1)$$

With the expansion of organizations and increasing the scope of supervision of managers, the evaluation and control of organizational units has become an inevitable necessity for managers. Basically, managers define the performance of sub-sectors by defining various indicators and measuring them. Although this evaluation conveys some meanings to the managers, but considering these indicators separately and ignoring the relationship between them will create an incomplete picture of the subject under study. One of the methods that can be done for this purpose is the output-driven BCC method. In data envelopment analysis (DEA), various methods are used to measure performance and performance, one of the most important of which is the BCC method, which is discussed below.

BCC model was introduced by Banker, Cooper and Charns in 1984, whose name is derived from the initials of their names. The difference between this model and the CCR model is in the assumption of variable returns relative to scale. At constant returns to scale, an increase in input leads to an increase in output by the same ratio. But in variable returns, the output increase is more or less the ratio of the increase in input. The same basics of building CCR models are used to build input-axis and output-axis models in the main BCC model. In input-driven models, the efficiency increases as the inputs decrease. But in output-driven models, the efficiency increases as the output increases.

The general BCC model is as follows:

$k = 1\ to\ s,$

$j = 1\ to\ m,$

$i = 1\ to\ n,$

$y_{ki=amount\ of\ output\ k\ produced\ by\ DMU\ i},$

$x_{ji=\ amount\ of\ input\ j\ utilized\ by\ DMU\ i},$

$v_{k=weight\ given\ to\ output\ k},$

$u_{j=}\ weight\ given\ to\ input\ j,$

$\mathcal{W} = (\mathcal{W}_1, \ldots, \mathcal{W}_q)$: The vector of weights for the intermediate measures

$$Z_0 = \text{Min} \sum_{i=1}^{m} v_i\, x_{i0} + w \quad (2)$$

(*s.t.*

$$\sum_{r=1}^{s} u_r\, y_{r0} = 1,$$

$$-\sum_{r=1}^{s} u_r\, y_{rj} + \sum_{i=1}^{m} v_i\, x_{ij} + w \geq 0,$$

$$u_r, v_{i \geq \varepsilon}.$$

In the skill training supply chain, as observed, there are two stages. In fact, the set of outputs of the first stage becomes the set of inputs in the second stage, and in general it can be said that the outputs of one stage of the process are inputs for the next one which is called intermediate stage. Therefore, the structure of the present research model is a two-stage network.

4.2. Network DEA model

Since the supply chain system in question is serial, we examine the types of structure of serial network systems:

Network systems with series structure:

Kao and Hwang [31] introduced a model for evaluating performance metrics for two-stage production units. The main contribution of their work is to decompose the overall efficiency score of a unit by multiplying the efficiency scores of

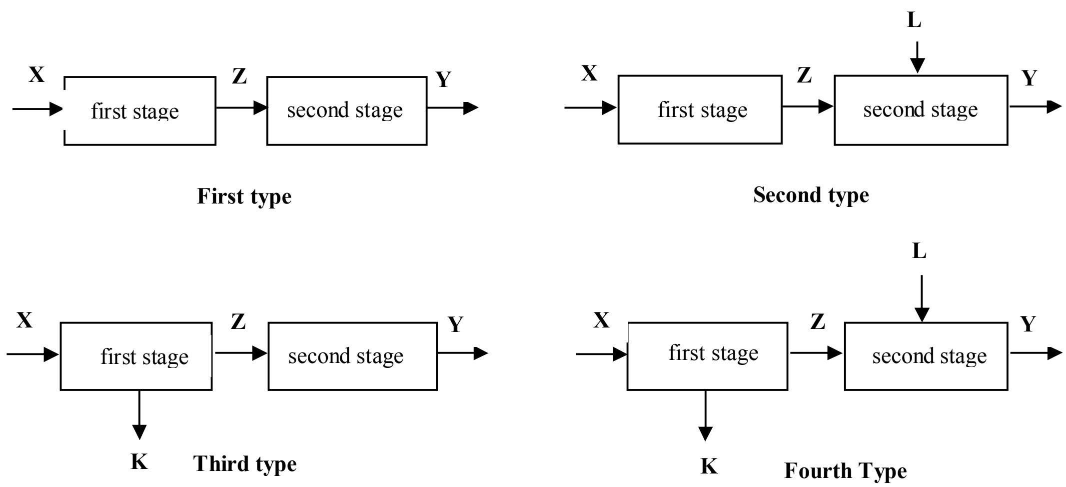

Fig. 2. Types of series two-step processes

The present research model is type 1 without additional inputs and outputs.

4.3. Problem formulation

Since various models of DEA have been developed over the years to be employed for variety of application areas, it is significant to develop an appropriate evaluation model for the proposed skill training supply chain. Due to the structure of the problem, we make use of the two-stage network DEA model developed by [31]. The reason is that the proposed skill training supply chain is a two layer one and thus to have an overall integrated efficiency evaluation it is necessary to formulate the method for each stage. Therefore, NDEA is adapted to the supply chain.

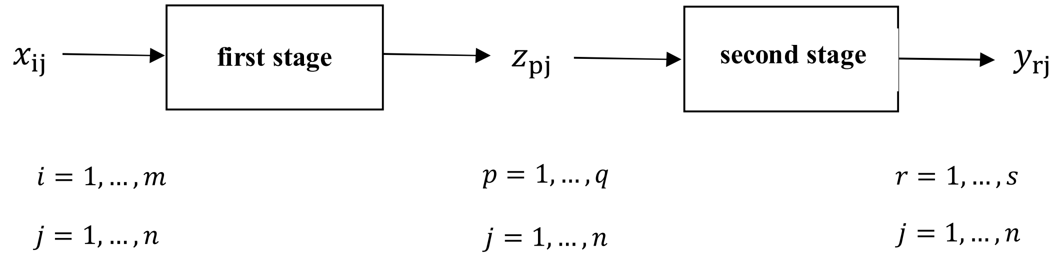

Fig. 3. Two-stage network structure

$j \epsilon J = \{1, \dots, n\}$: *The index set of the n DMUs.*
$j_0 \epsilon J$: *Denotes the evaluated DMU.*
X_{ij} = *The vector of stage − 1 external inputs i used by DMU j.*
Z_{pj} = *The vector of intermediate measures p for DMU j.*
Y_{rj} = *The vector of stage − 2 final outputs r prodused by DMU j .*
$v = (v_1, \dots, v_m)$: *The vector of weights for the stage − 1 external inputs*
$w = (w_1, \dots, w_q)$: *The vector of weights for the intermediate measures*
$u = (u_1, \dots, u_s)$: *The vector of weights for the stage − 2 outputs.*
$E_j^{1(vrs)}$ *The efficiency of the first stage for DMUj.*
$E_j^{2(vrs)}$ *The efficiency of the second stage for DMUj.*
$E_j^{(vrs)}$ *The overall efficiency of DMUj.*
In the skill training supply chain mentioned above, we have:
$i = \{1,2, \dots, 9\}$
$p = \{1,2, \dots, 11\}$
$r = \{1,2, \dots, 5\}$
$j = \{1,2, \dots, 5\}$

x_{ij} (Level 1 components): Higher education graduates (skill training instructors), training equipment and training aids, consumables, training workshop, training course, center overhead cost (water-electricity-gas), training support force, training content (Skills training standards), training portal, library, restaurant, dormitory

z_{pj} (Level 2 components): Career counseling and guidance, training planning (part of the standard, full standard, module), training model design (participatory, dual training, apprenticeship, real-time skills training, general training), Forms of education (instructor training, in real work environment, while working, workshop neighborhood, inter-workshop, university neighborhood, fixed government centers, urban mobile, rural mobile, barracks and prison) and theoretical and practical evaluation

y_{rj} (Level 3 components): training outcome (self-employed, employed, employed), final product (certifications issued, certificates of proficiency issued)

Consider the initial state (type I) in which each DMU converts X external inputs to final Y outputs through intermediate Z criteria by a two-step process, as shown in Figure (2). In these initial settings, nothing enters the system except the first stage inputs and nothing leaves the system except the second stage outputs.

Typically, the performance of DMU j is first defined as follows:

$$E_j^{1(vrs)} = \frac{\sum_{p=1}^{q} w_p z_{pj}}{\sum_{i=1}^{m} v_i x_{ij}} \tag{3}$$

The performance of DMU j in the second step is defined as follows:

$$E_j^{2(vrs)} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{p=1}^{q} w_p z_{pj}} \tag{4}$$

The overall performance of DMU j is defined as follows:

$$E_j^{(vrs)} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \tag{5}$$

The efficiency of the DMU k system in the BCC model is determined by maximizing it under the limit that for all DMUs, the efficiency of the two processes and the system is less than or equal to one. The NDEA in the BCC model is as follows:

$$max\ E_k^{(vrs)} = \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ij}}$$

s.t. $E_j^{1(vrs)} = \frac{\sum_{p=1}^{q} w_p z_{pj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, j = 1, \dots, n$

$$E_j^{2(vrs)} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{p=1}^{q} w_p z_{pj}} \le 1, j = 1, \dots, n \quad (6)$$

$$E_j^{(vrs)} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1, j = 1, \dots, n$$

$v_i \ge 0, i = 1, \dots, m$
$w_p \ge 0, p = 1, \dots, q$
$u_r \ge 0, r = 1, \dots, s$

By applying the linearization technique to the above model, we have:

$$max\ E_k^{(vrs)} = \sum_{r=1}^{s} u_r y_{rk}$$

s.t. $\sum_{i=1}^{m} v_i x_{ik} = 1$

$$\sum_{p=1}^{q} w_p z_{pj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, j = 1, \dots, n \quad (7)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{p=1}^{q} w_p z_{pj} \le 0. j = 1, \dots, n$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, j = 1, \dots, n$$

$v_i \ge 0, i = 1, \dots, m$
$w_p \ge 0, p = 1, \dots, q$
$u_r \ge 0, r = 1, \dots, s$

After simplifying the above model, the adapted NDEA for the proposed skill training supply chain is obtained as follows:

$$max\ E_k^{(vrs)} = \sum_{r=1}^{s} u_r y_{rk}$$

s.t. $\sum_{i=1}^{m} v_i x_{ik} = 1$

$$\sum_{p=1}^{q} w_p z_{pj} - \sum_{i=1}^{m} v_i x_{ij} \le 0, j = 1, \dots, n \quad (8)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{p=1}^{q} w_p z_{pj} \le 0, j = 1, \dots, n$$

$v_i \ge 0, i = 1, \dots, m$
$w_p \ge 0, p = 1, \dots, q$
$u_r \ge 0, r = 1, \dots, s$

The loss resulting from the decision is also obtained from the following formula:

$$g_j^{1\,(crs)} = \sum_{i=1}^{m} v_i x_{ij} - \sum_{p=1}^{q} w_p z_{pj}$$

$$g_j^{2\,(crs)} = \sum_{p=1}^{q} w_p z_{pj} - \sum_{r=1}^{s} u_r y_{rj}$$

$$g_j^{(crs)} = \sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \quad (9)$$

Model (8) is the adapted NDEA for the efficiency evaluation purpose. This model evaluates the efficiency in each layer of the supply chain based on the performance and provides feedbacks. Further, the overall efficiency of the whole supply chain based on the final user skills is obtained. According to Model (9), with respect to the performances in each layer of the supply chain (each stage of the NDEA), the loss incurred by the performance is computed. This loss computation helps decision makers to determine the drawbacks in the skill training and prepare appropriate feedback.

5. Implementation and Analysis

This study was conducted for five popular standards in the industry cluster in Iran skills training and for five influential provinces in the field of industry, including Alborz, East Azerbaijan, Isfahan, Khorasan Razavi and Tehran as DMUs. LINGO software was used to analyze the data.
Using the input data in Tables 2, 3 and 4, the proposed network model is optimized in LINGO software. The results computed by Model (8) are shown in Table 5.

Tab. 2. Input data X

DMU	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10
Auto Mechanic	42	150	340	35	37	140	210	5	35	35
Electricity	25	250	285	23	23	92	138	5	23	23
Turning	17	160	250	16	17	64	96	5	16	16
Welding	29	130	160	25	28	96	142	5	25	25
Building drawing	9	60	35	11	11	44	66	5	12	12

Tab. 3. Input data Y

DMU	z1	z2	z3	z4	z5
Auto Mechanic	995	5	995	37	995
Electricity	342	5	342	23	342
Turning	266	5	266	17	266
Welding	473	5	473	28	473
Building drawing	185	5	185	12	185

Tab. 4. Input data Z

DMU	y1	y2	y3	y4
Auto Mechanic	87	108	65	174
Electricity	29	38	24	59
Turning	24	28	19	46
Welding	43	56	34	87
Building drawing	23	31	18	43

Tab. 5. Results obtained

DMU	loss of stage 1	loss of stage 2	loss of system	efficiency of stage 1	efficiency of stage 2	efficiency of system
Auto Mechanic	0.354	0.484	0.838	0.646	0.252	0.163
Electricity	0	0.25	0.25	1	0.75	0.75
Turning	0.329	0.465	0.794	0.671	0.308	0.207
Welding	0.331	0.382	0.713	0.669	0.43	0.287
Building drawing	0	0.387	0.387	1	0.613	0.613

In Table 5, the best performance according to efficiency is related to the field of electricity, which also has the least loss, due to the maximum efficiency in the first stage. The lowest efficiency is related to auto mechanics. It can be explained that according to the components of the supply chain of skills training that were used in this research, which were fully addressed in the problem formulation section, the results were obtained as well as the reasons for the low efficiency of the field. The issues discussed include the lack of workshop equipment appropriate to the needs of the labor market, lack of sufficient consumables due to lack of budget, inadequate knowledge and experience of trainers with skilled craftsmen and up-to-date technological changes, lack of insurance for graduates working in repair shops. We can also mention the skills of the graduates who have started the business in question and the lack of accurate information in tracking the employment of the job monitoring staff. Another point is that most of the skill courses in the fields of electricity, building drawing, welding and turning are order-oriented and tailored to the needs of the labor market, while most courses offered in the field of auto mechanics are supply-oriented and therefore most of the skills learned. There are four required market disciplines that lead to employment.

It should be mentioned that loss in each stage and the total loss of the system are computed using model (9). It should be emphasized that loss computation helps decision makers to determine the drawbacks in the skill training and prepare appropriate feedback

Note that the system loss is the sum of the losses of the two stages. On the other hand, the efficiency of the system is the product of the efficiency of two stages. To validate the results, we can also use the relation:

E=1-g also compared the results (although a slight difference is due to the rounding error).

The following is the analysis of the results:

In output-driven models, the efficiency increases as the output increases.

1. If w <0, the type of return to scale is decreasing.
2. If w = 0, the type of return to scale is constant.
3. If w> 0, the type of return to scale is increasing.

where w is the efficiency;

Also:

1. When g <0 indicates high performance.
2. When g = 0 indicates maximum efficiency.
3. When g> 0 indicates low performance.

where g is the loss.

In this model, both w and g are positive and thus a trade-off between two values for each DMU is required to analyze the efficiency of the whole supply chain. As mentioned, the best performance according to efficiency is related to the field of electricity, which also has the least loss, due to the maximum efficiency in the first stage

6. Conclusions

The supply chain of skills training was implemented on the most popular skills standards for industry. The existing standards in those areas, according to the complete and comprehensive supply chain designed in this research, implemented and exploited the results. It is worth noting that according to the standards used or clusters in future research, the use of components of the supply chain of trained skills training will also be different and according to the necessity of using each research of the effective components in the same field will be used. The best performance according to efficiency is related to the field of electricity, which also has the least loss, due to the maximum efficiency in the first stage. The lowest efficiency is related to auto mechanics. It can be explained that according to the components of the supply chain of skills training that were used in this research, which were fully addressed in the problem formulation section, the results were obtained as well as the reasons for the low efficiency of the field. Further the following research limitations were considered during data collection and implementation process:

- Lack of immediate access to skills experts due to their busy schedule, to think and apply their opinions, which led to a longer research time. Of course, by planning and spending time, we were able to apply the valuable suggestions of skill experts at the end of each research topic and satisfy them.
- Access to statistics and information related to research, which took time to solve infrastructure problems, but finally, by solving the problem, we were able to collect the desired data.
- This research has been done on the most popular standards of industry clusters, so it can be generalized for other standards and different clusters and the results obtained in other sectors can be used.
- Since no research has been done in the field of supply chain training of skills so far, the resources used in this field are limited or related to the supply chain of other trainings such as higher education in universities and trainings offered in Schools and etc. There were also resources for previous years, which means that there are no resources to compare the results that can be used to strengthen the research. However, due to the very important role of skills in human resource training, this research by evaluating the training process through a supply chain is considered a new beginning for future research in the field of skills training.

As for future research direction, it is suggested to include uncertainty in data and decision making, design of a feedback system to make use of performance evaluation and develop improvement policies.

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